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Scallop Production Area 3: Stock status update for 1998

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Abstract

This document reviews the data from the 1998 fishery and 1998 survey for Scallop Production Area (SPA) 3 (Brier Island/Lurcher Shoal). Landings in SPA 3 increased each year from 1990 to 1994 and have steadily declined since. The 1998 landings were 162 t for a TAC of 150 t. Unlike the previous year, fishing effort in 1998 was mainly located in the northeast corner of the Brier Island subarea along the boundary with SPA 7 (St. Mary's Bay). Consequently, the largest portion of the catch came from this same area, however the associated catch rates tended to be in the lower end of the range observed. Given that this area is shallow and scallops caught here exhibit high meat yield, it appears that the fleet was targetting larger scallops for the higher prices being paid for them despite the lower catch rate. There was minimal port sampling data in 1998 due to lack of voluntary participation by the fleet. The survey indicated a small increase in abundance of scallop greater than 80 mm in the Brier Island area but little change in the Lurcher area. There were some signs of recruitment in both areas, mainly along the western edge where meat yields tend to be low. A re-analysis of spatial patterns in shell height and age data suggests that the previous age composition estimates may not be appropriate. Without age composition, exploitation rates could not be calculated. The 1999 TAC has already been set at 200 t for SPA 3 and 7, which have been combined in 1999 for fisheries management purposes. Based on population size structure for meat weights estimated from the survey, there is no reason to change the TAC for 1999.

Résumé

Le présent document traite des données de la pêche et du relevé de 1998 du pétoncle dans la zone de production du pétoncle (ZPP) 3 (île Brier et Lurcher Shoal). Les débarquements en provenance de la ZPP 3 ont augmenté à chaque année de 1990 à 1994 pour ensuite décliner de façon constante. Les débarquements de 1998 se sont élevés à 162 t, pour un TPA de 150 t. Au contraire de l'année précédente, l'effort de pêche de 1998 a surtout été concentré dans le coin nord-est de la sous-zone de l'île Brier le long de la limite avec la ZPP 7 (baie St. Mary's). La plus grande proportion des captures provenait donc de cette région, mais les taux de capture avaient tendance à se situer dans le bas de la gamme. Étant donné que cette zone est peu profonde et que les pétoncles capturés présentent un rendement en chair élevé, il semble que les pêcheurs recherchaient les plus gros pétoncles pour leur prix plus élevé, en dépit de taux de capture inférieurs. Les données d'échantillonnage au port pour 1998 sont rares à cause du peu de collaboration des pêcheurs. Le relevé montre une petite augmentation de l'abondance des pétoncles de plus de 80 mm dans la région de l'île Brier, mais peu de variation dans celle de Lurcher. Il y avait certains indices de recrutement dans les deux zones, surtout le long du bord ouest où le rendement en chairs avait tendance à être faible. Une nouvelle analyse de l'allure spatiale des données sur la hauteur des coquilles et l'âge porte à croire que l'estimation antérieure de la composition pourrait ne pas être adéquate. Il était impossible de calculer le taux d'exploitation sans connaître la composition par âges. Le TPA de 1999 a déjà été fixé à 200 t pour les ZPP 3 et 7, qui ont été combinées aux fins de la gestion des pêches de 1999. Rien n'indique qu'il y ait lieu de modifier le TPA

pour 1999, si l'on se fonde sur la structure de la population en fonction du poids des chairs qui a été estimée à partir des données du relevé.

Introduction

On 1 January 1997, an area-based management plan was implemented for the scallop fishery in the Bay of Fundy dividing the Bay into 7 Scallop Production Areas (SPAs; Fig. 1A). Historically, scallop fishing in SPA 3, which encompasses the outer reaches and approaches to the Bay of Fundy, has been sporadic and mainly supported by intermittent recruitment. This area was heavily exploited in the 1950's and 1960's but after that fishing was minimal until 1980 when both the inshore (LOA under 19.8 m) and offshore (LOA over 19.8 m) fleets fished the area until 1986. In 1986 an agreement was reached between the two fleet sectors to separate fishing grounds as inshore grounds being north and offshore grounds being south of latitude 43° 40' N. After 1986, the inshore fleet did not fish the area now known as SPA 3 until 1991 probably due the record catches being made on the Digby beds in the late 1980's. Since 1991, landings from the area south of Brier Island have made up a significant proportion of the total landings of the inshore fleet.

This document reports on the 1998 scallop fishery for SPA 3 with respect to trends in the landings, effort and population abundance trends as indicated by the research survey.

Commercial Fishery

A portion of SPA 3 was opened to the scallop fishery in 1998 from 20 April to 31 May (Fig. 1B) with the entire area opening up thereafter until 21 September. The meat count regulation was set at 40 meats per 500 gm with a minimum shell height of 100 mm. Preliminary statistics for 1998 give a total landing of 162 t for a 150 t TAC. Logbook data indicate that the average catch rate was 8.9 kg (meats)/hour with sixty-two vessels reporting fishing in the area.

The assignment of landings from years prior to 1997 to the current boundaries of SPA 3 have been problematic due to the lack of precise physical location information in the landings data collected by Statistics Division and variable compliance of the submission of fishing log information (13–100 percent). The total catch assigned to any SPA was estimated based on the assumption that the catch from known locations (from complete fishing log information) was representative of the total catch by the Full Bay licence holder fleet. With the introduction of a dockside monitoring system and hailing requirements, discrepancies and problems associated with assigning catch to area have been greatly reduced since 1997.

Landings steadily increased in SPA 3 from 1991 to 1994 (1994 was probably an overestimate due to misreporting of catch from below 43° 40′ N) but have declined since then. Note that the TAC of 200 t for 1999 has been set as a combined TAC for SPA 3 and SPA 7 (St. Mary's Bay) for management purposes.

Area 3 Landings (metric tons meats)

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	0	451	827	991	1382	767	200	190	162[1]	
Kg/h		20.8	19.5	20.9	16.8	10.7	9.2	7.1	8.9	
TAC								237	150	200[2]

[1] Preliminary

[2] TAC for SPA 3 and 7 (St. Mary's Bay) have been combined for 1999.

Catch rates (kg meats/hour) based on data from Class 1 logs (logs with complete information) have been decreasing since 1993 but showed a slight increase in 1998 (Fig. 2a). Based on historical fishing patterns, SPA 3 is divided into two subareas with the Brier Island subarea being north of 44°N Latitude and Lurcher shoal being the southern subarea. The proportion of the total fishing effort expended into each of these areas has varied somewhat over time but 1997 saw an unusual concentration of effort in the Lurcher shoal subarea (Fig. 2b). In 1998, there was more effort in the Brier Island subarea but the total effort for the areas combined decreased over that recorded for 1997. The spatial distributions of catch, effort and catch rate reported from Class 1 logs were mapped in Figs. 3 to 5, respectively. In 1998, the largest proportion of the catch and effort was in the shoal water area of the Brier Island subarea (Figs. 3 and 4) but this was not the area of the highest catch rates (Figs. 5). The shoal water area of the Brier Island subarea generally has high meat yield and growth. Currently, higher prices are being paid for larger scallop meats. This practice along with the fleet operating under Individual Transferable Quotas appears to have lead to targeting on larger scallops. Over all, this grading practice may have a significant impact on fishing strategy depending upon the availability of larger scallops and the price differential according to size of the meats.

Port Sampling of Commercial Catch

Sampling of commercial catch for meat size composition has been carried out by the department for landings in ports from Digby to Yarmouth. Vessels are sampled on an opportunistic basis. Two samples of approximately 500 gm each are removed from the catch of each sampled vessel. The date, vessel name, location and depth fished are recorded for the samples. The port sampler removes the catch muscle from the adductor muscle and each adductor muscle is weighed and counted for the two samples. Catch muscles are removed from the sample meats because they are often removed by commercial processing in many areas. Catch muscles are estimated to be 5 to 7 percent of the total weight of adductor and catch muscle. The mean, standard deviation and range of meat weights are calculated on a monthly basis when data are available. Samples are only approximately 500 gm and therefore a meat count of the sample is calculated by dividing 500 gm by the average weight of the meats in the actual sample.

The total number of samples of landings from throughout the Bay had increased from 1995 to 1997 with an improvement in increasing the number of boats being sampled. The number of samples decreased dramatically in SPA 3 in 1998 because of the refusal by many vessels to supply samples voluntarily to the port samplers.

Year	No. Samples	No. Vessels	% from 2 vessels	% from 3 vessels	% from 4 vessels
1995	104	9	58.7	77.9	85.6
1996	206	27	27.7	34.9	41.7
1997	339	50	16.2	22.7	28.6
1998	107	17	34.6	50.5	63.6

Average meat weight, range, standard deviation and meat count are presented in Table 1 for Brier Island and Lurcher Shoal subareas. Overall, the meat count in Brier Island declined

from 1997 to 1998 while it appeared to remain unchanged in Lurcher. Meat counts were lower in Brier Island than Lurcher shoal in 1998. The distribution of meat weights from the samples are plotted in Figs. 6 and 7.

In addition to the decrease in the number of samples, there was also the problem with the fact that most of the samples that were collected came from the shallow, nearshore areas of SPA 3 (Fig. 8).

With the decrease in the number of samples taken, these data can only be used for a general description of the fishery and can not be used to provide absolute estimates of total removals by meat size class. Without a substantial increase in temporal and spatial coverage this type of data will be of limited use.

Research Surveys

Annual stock surveys have been conducted every August since 1991 using the research vessel J.L. Hart. The four-gang dredge gear configuration has remained unchanged throughout the survey series (Kenchington et al. 1997). However, the survey design and amount of area covered have changed over time. The survey followed a grid pattern from 1991 to 1996 with area surveyed expanding each year (Kenchington and Lundy 1998). The survey used random locations for stations in 1997 and 1998. The area covered by the surveys has been comparable since 1995.

As in previous surveys, two of the four dredges were lined with 38 mm polypropylene stretch mesh. Catches in the lined gear were used to estimate the abundance of scallops with shell height less than 80 mm while the catches from the unlined gear were used to estimate the abundance of scallops with shell heights greater than 80 mm. Catches of scallops with shell heights less than 40 mm are thought to give qualitative indications of abundance only, due to uncertainties about catchability of the small animals. All catches are prorated to the expected catch of a seven-gang gear rig (common commercial rig) and numbers are standardized to a standard tow length of 800 m. Vessel malfunctions resulted in only 100 of the assigned 120 tows being completed for the 1998 survey. Survey coverage of the neighbouring St. Mary's Bay (SPA 7) was also cancelled due to these vessel problems.

Survey Abundance

The spatial distribution of scallops for shell height size groups greater than 80 mm and less than 80 mm are presented in Figs. 9 to 10, respectively for 1995 to 1998. As in previous surveys, the higher densities of scallops with shell heights greater than 80 mm in 1998 are concentrated in the western portion of the survey area with highest densities of scallops in this size group being west of 66° 40'W. However, the patterns for the smaller scallops (less than 80 mm) appears to be quite different between the two years. In 1997, the greater concentration of the smaller scallops mainly lay to the east of 66° 35'W but in the 1998 survey the largest concentrations are almost all to the west of this longitude.

Tow locations for the survey are indicated on Fig. 10 where it shows that survey coverage needs to be extended inshore in the future to cover these areas (vessel problems did result in

loss of planned coverage in this area). Recall from Fig. 4, that the increase in fishing effort in these areas appears to be a recent phenomena in the short period from 1995.

The shell height compositions for the average number per tow are plotted in Figs. 11 and 12 for Brier Island and Lurcher shoal, respectively. Relative to 1996, there are indications of strong recruitment in Brier Island for size classes less than 50 mm. However, as indicated above these indications are qualitative at best. The progression of mean number per tow with size in Brier Island from the 1996 to 1997 survey does not appear to make sense. The apparent increase in numbers for shell heights of 80 to 100 mm in 1997 was not preceded by large numbers of scallops with smaller shell heights in 1996. In 1998, the mean number per tow increased for shell heights greater than 90 mm but this increase was greater than expected given the abundance of scallops with shell heights less than 90 mm in 1997.

The trends in size composition for Lurcher Shoal were similar to those in Brier Island with qualitative signs of good recruitment in 1997 and 1998 for scallops with shell heights less than 50 mm. In addition the mean numbers per tow for shell heights greater than 90 mm appear to be larger than anticipated given the numbers observed at shell heights less than 90 mm.

The prorated numbers of scallops with shell heights less than 80 mm, greater than 80 mm and the total for all sizes are presented in Table 2. The estimates for the two size groups are plotted against time in Fig. 13 along with 95 percent confidence intervals calculated using bootstrap resampling and BCa percentiles (Efron and Tibshirani 1993). The variability of the mean estimate appears to have increased in 1997 and 1998 in the Brier Island subarea. Bootstrap confidence intervals don't have to be symmetric and it is interesting to note that the variability for both size classes in the Brier Island increase in the latter two years with the increase mainly occurring in the upper confidence limit. Estimates from Lurcher do not exhibit a similar trend.

Given the observed variability of the estimates there does not appear to be strong evidence for significant trends in abundance in the Lurcher subarea. Abundance for both size groups is slightly higher in 1997 and 1998 compared to 1995–96 in the Brier Island subarea.

Survey Biomass Estimates

Data on meat weights and age composition of the scallops caught in the survey have only been collected from each tow since 1996. In past assessments of this stock (e.g., Kenchington and Lundy 1998, Kenchington et al1997), meat weight per tow and total biomass of meat weights in the area were estimated using meat weight/shell height regressions from the 1996 survey data. There were six regression equations developed for various area and depth range combinations. These area and depth range combinations were also used to develop growth relationships using Von Bertalanffy equations, which in turn were used to estimate average shell height-at-age. Average weight-at-age was estimated using the regression equations applied to average shell height-at-age. Finally, numbers-at-age in each tow and average height-at-age were multiplied and then summed to give total meat weight for each tow. Population meat weights were obtained by converting the weight per tow for the area of the tow to the total area of the survey.

We have had the opportunity to explore the fit of these regression equations further and discovered very strong spatial patterns in the residuals from these equations. In Fig. 14, the studentized residuals of the original regression equations (Venables and Ripley 1998) are plotted for combinations of ranges of longitude (decimal) and depth. Columns in the figure correspond to longitudinal ranges with east being at the left side of the graph and west on the right. Depth ranges correspond to rows and increase from the bottom to the top of the graph. Scallops with shell height less than 50 mm are not included here due to the high variability associated with and the probable inaccuracy of the observed meat weights for the smaller animals. The main patterns in this figure show that the regression models underestimate meat weight in the eastern areas and especially in the shallower depths (leftmost columns). The three columns to the right in the figure show a tendency for the regression equations to overestimate meat weight in the west and exhibit a very strong overestimation for animals greater than 90 mm ($\log(90) = 4.5$) especially at but not limited to the deeper depths. The residual patterns for animals greater than 90 mm suggests that the trend for meat weight for increasing shell height is either flat or decreasing in the western areas. Residuals are also plotted on a map of the area in Fig. 15. As indicated in Fig. 14, there is a general progression of positive (underestimation) to negative (overestimation) residuals going from east to west. Analysis of the 1997 and 1998 data (not shown here) demonstrate almost identical trends. Kenchington and Lundy (1996) identified the area west of 66° 40′ W as an area where scallops of low condition were found presumably due to the very weak residual currents induced by the M2 tide in that area.

The residuals from the Von Bertalanffy curves also demonstrate strong spatial patterns with respect to area and depth (Fig. 16). The tendency shown by the residuals is for shell height-at-age to be underestimated in the eastern side of the area, especially for the older animals and then to overestimate shell height in the western end. Actual meat weights-at-age are given below for scallops on either side of the 66° 40′ W line based on observed weights for known age scallops from the 1996 survey. Note for both Brier and Lurcher, there is an apparent lack of growth after age 7 for scallops located west of 66° 40′ W which was also indicated by the residuals in Fig. 14.

The weights-at-age for animals found west of 66° 40′ W differ substantially from the overall average weights presented on page 6 of Kenchington and Lundy (1998). Given that 58 percent of the scallops caught in Lurcher shoal were caught west of this line and Lurcher accounted for 75 percent of the survey catch, overall biomass estimated using the above will be lower than estimated in Kenchington and Lundy (1998). However, ages are not available yet for the 1997 and 1998 surveys and therefore it is not possible to recalculate total meat weights over all years from actual ages.

In 1996 and 1997 meats from all scallops caught in the survey were weighed whereas in 1998 only two meats per 5 mm shell height category were weighed per tow. However sampled average weights can be calculated for each shell height class (5 mm categories) for each tow in all three surveys and meat weight per tow and average meat weight per tow over the whole survey can be estimated directly from the data without the need of a model. The average meat weights per tow for scallops with shell heights greater than 80 mm are 505, 616, and 711 gm for Brier and 646, 866 and 750 gm for Lurcher, for 1996, 1997 and 1998, respectively.

In a similar manner, the meat weight frequency distribution of the mean number of scallops per tow can be calculated for the same years (Fig. 17). Comparison of the these frequencies for each subarea over the three years do not appear to indicate any substantial change in the number of large meats even with the targetting in the 1998 fishery (survey completed after most of the fishery has taken place).

Summary

1. Landings in SPA 3 for 1998 were 162 t for a TAC of 150 t. A TAC of 200 t has been set for 1999 for SPA 3 and 7 combined. In 1998 the individual allocations were 150 for SPA 3 and 50 t for SPA 7.

2. In 1998, catch and fishing effort was concentrated on the eastern portion of the Brier Island subarea. However, these were not necessarily the areas of the highest catch rates.

3. Port sampling of the commercial catch indicated targetting of large scallops in the eastern portion the Brier Island subarea. Port sampling coverage declined in 1998 threatening the usefulness of these kind of data.

4. Analysis of shell height meat weight regressions and growth curves indicated strong spatial patterns that need to be understood and incorporated to improve the utility of these models. According to size-at-age data from the 1996 survey, the adductor muscle (meat) does not increase in weight for scallops in the area west of 66° 40′ W after the age of 7 years.

5. Research survey indicates a very small increase in numbers per tow in 1998 for scallops in the Brier island subarea but little change in Lurcher Shoal. Maps of the spatial distribution show that the higher densities for all sizes are found in the western side of the survey area. Scallops from the western side exhibit low growth rates and yield.

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Table 1: SPA 3 (Brier Island/Lurcher Shoal) Meat Weight Statistics for the Full Bay Licence Holders by Month and Year Calculated from Port Samples of the Commercial Catch.

		Meat weight (g)				Sample size	Meat count
Year	Month	Mean	Min.	Max.	s.d.	(n meats)	per 500 g
Brier Island Fishing Grounds							
1983	May	10.62	3.7	18.0	3.20	85	47.1
	June	9.00	4.0	27.2	4.19	106	55.6
1991	May	13.55	6.5	38.8	5.70	74	36.9
	June	20.23	4.5	37.6	6.93	50	24.7
1992	June	12.91	5.6	26.2	4.03	77	38.7
	July	13.36	2.8	59.2	8.86	434	37.4
	Sept.	8.64	3.8	17.0	2.12	583	57.9
1993	April	12.50	3.3	25.6	4.74	318	40.0
	May	10.59	3.4	29.6	5.99	280	47.2
	June	9.98	3.9	26.7	3.58	200	50.1
	Sept.	11.31	3.6	42.9	6.51	379	44.2
	Nov.	14.00	7.3	23.7	3.37	71	35.7
1994	March	20.91	9.3	37.0	6.75	53	23.9
	April	19.00	4.9	42.0	7.64	419	26.3
	May	13.64	5.5	22.0	3.20	292	36.7
	June	16.18	4.6	51.5	7.26	1055	30.9
	July	22.00	11.0	37.5	6.30	111	22.7
1996	May	10.80	2.9	25.9	4.33	155	46.3
	July	19.80	15.8	23.9	2.17	35	25.3
	August	15.48	11.1	24.1	3.19	37	32.3
1997	May	13.46	6.3	24.4	4.05	120	37.1
	June	12.46	3.2	38.8	4.79	652	40.1
	July	15.05	5.1	41.7	5.47	1102	33.2
	August	13.96	4.4	45.1	7.64	266	35.8
	Sept.	35.27	21.9	49.0	7.94	36	14.2
	October	17.58	8.2	32.4	6.51	53	28.4
1998	June	18.19	6.5	28.7	2.88	594	27.5
	July	16.06	5.2	43.8	5.64	374	31.1
Lurcher Shoal Fishing Grounds							
1991	June	6.67	2.2	27.6	1.95	1210	75.0
	July	9.17	3.1	33.7	5.15	437	54.5
	August	7.73	3.7	25.5	3.09	134	64.7
1992	June	9.84	3.3	29.0	3.86	312	50.8
	July	10.88	2.5	38.4	4.59	907	46.0
	August	15.20	9.4	27.0	2.75	66	32.9
	Sept.	9.17	4.6	15.7	2.14	446	54.5

Table 1: SPA 3 (Brier Island/Lurcher Shoal) Meat Weight Statistics, cont'd

1993	April	8.89	3.0	23.8	3.79	225	56.2
	May	7.00	3.0	25.3	2.44	711	71.4
	June	8.21	3.1	17.0	2.02	122	60.9
	Sept.	10.04	3.5	27.8	3.96	597	49.8
	Nov.	14.06	6.1	30.4	4.77	142	35.6
1994	April	15.72	5.6	43.5	7.10	380	31.8
	May	14.40	3.6	32.3	3.80	851	34.7
	July	12.31	4.8	34.3	4.05	971	40.6
1995	June	16.64	5.5	26.7	4.69	59	30.0
	July	14.33	5.7	29.3	4.61	344	34.9
	August	14.16	5.8	24.8	4.37	78	35.3
1996	June	11.83	4.3	29.2	4.01	350	42.3
	July	13.30	4.0	37.1	5.89	279	37.6
	August	17.58	10.4	25.3	3.34	75	28.4
	Nov.	12.40	5.1	28.0	4.30	243	40.3
1997	May	10.87	3.2	33.7	4.01	951	46.0
	June	13.11	3.5	40.9	5.74	874	38.1
	July	12.96	3.7	38.4	5.08	1015	38.6
	August	13.08	4.0	38.4	6.30	232	38.2
	Sept.	11.58	3.3	33.5	4.99	217	43.2
	October	14.79	5.1	32.4	5.44	125	33.8
1998	June	14.45	4.4	47.6	6.75	255	34.6
	July	12.38	4.3	55.1	5.14	531	40.4
	August	13.74	5.4	25.4	5.08	135	36.4

Table 2. Mean numbers per tow for the 1996–1998 scallop surveys in SPA 3. Percentage of clappers shown in brackets.

		Shell Height (mm)			
Subarea	Year	< 80	≥ 80	All sizes	No. of tows
Brier Island	1998	39.06	74.85	113.92(6.0)	31
	1997	51.14	58.29	109.43(4.8)	47
	1996	13.27	46.34	59.61(7.3)	45
	1995	15.17	54.69	69.86(8.1)	42
Lurcher	1998	32.92	108.95	141.87(3.8)	69
	1997	47.76	113.91	161.68(5.4)	73
	1996	35.07	89.61	124.67(11.1)	69
	1995	43.68	137.44	181.13(16.8)	60
Total	1998	34.82	98.38	133.20	100
	1997	49.08	92.13	141.21	120
	1996	26.46	72.53	98.99	114
	1995	39.73	108.36	148.09	102

Table 3. Average weight-at-age (gm) from 1996 survey of SPA 3. KL refers to the estimates from Kenchington and Lundy (1998), page 6.

	Brier			Lurcher		
	66°40′W			66°40′W		
Age	East	West	KL 1998	East	West	KL 1998
1	0.33	–	0.11	0.23	0.15	0.18
2	0.98	2.70	0.97	1.02	1.12	1.06
3	3.19	4.60	2.80	3.23	2.71	2.89
4	6.36	4.60	5.72	4.95	4.84	4.65
5	9.75	6.94	8.17	7.55	6.94	6.63
6	12.56	8.88	10.19	10.17	8.53	8.34
7	14.18	10.40	11.99	11.77	9.49	9.54
8	15.76	10.42	13.58	13.08	8.91	10.62
9	17.05	10.40	14.73	14.35	8.40	11.86
10	17.56	9.28	19.09	15.44	7.45	15.52

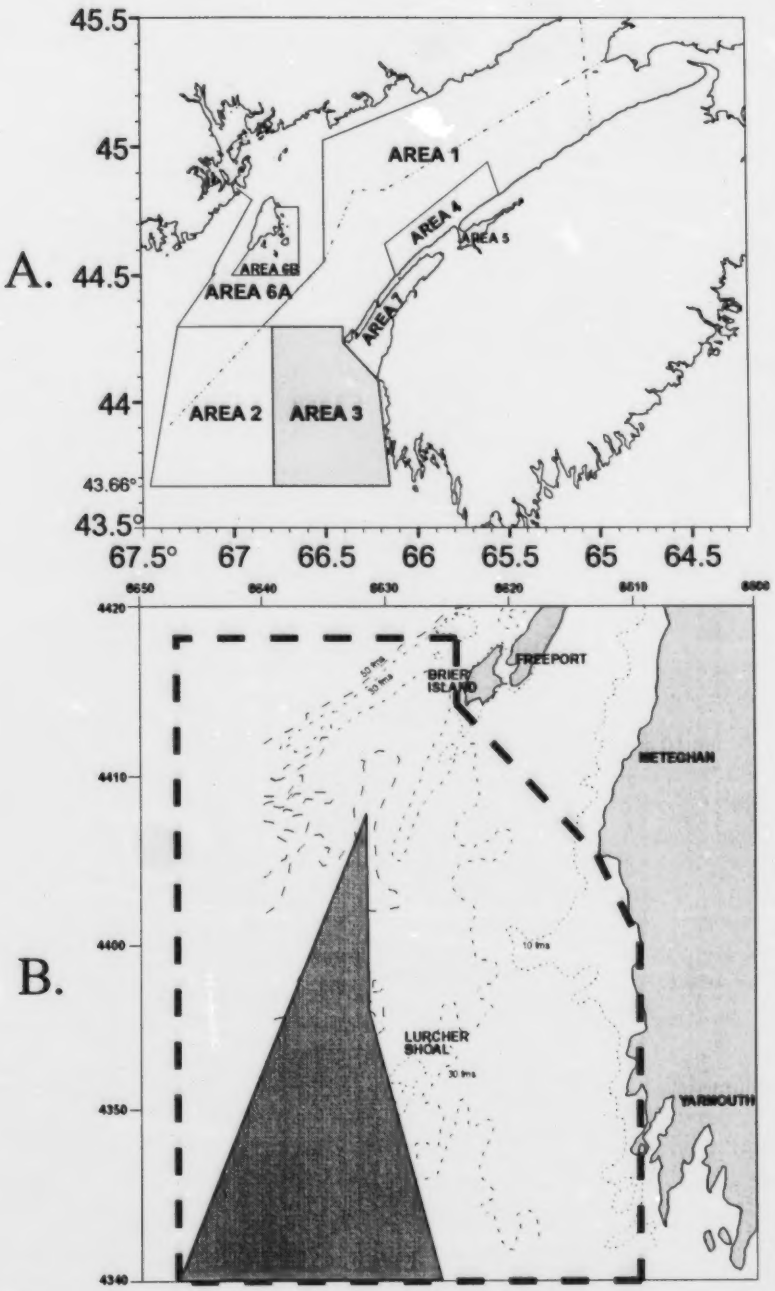

Fig. 1. A. Scallop Production Areas in the Bay of Fundy. B. Scallop Production Area 3 shaded area open April 20, 1998 to May 31, 1998 and dashed area open June 1, 1998 to Sept. 20, 1998.

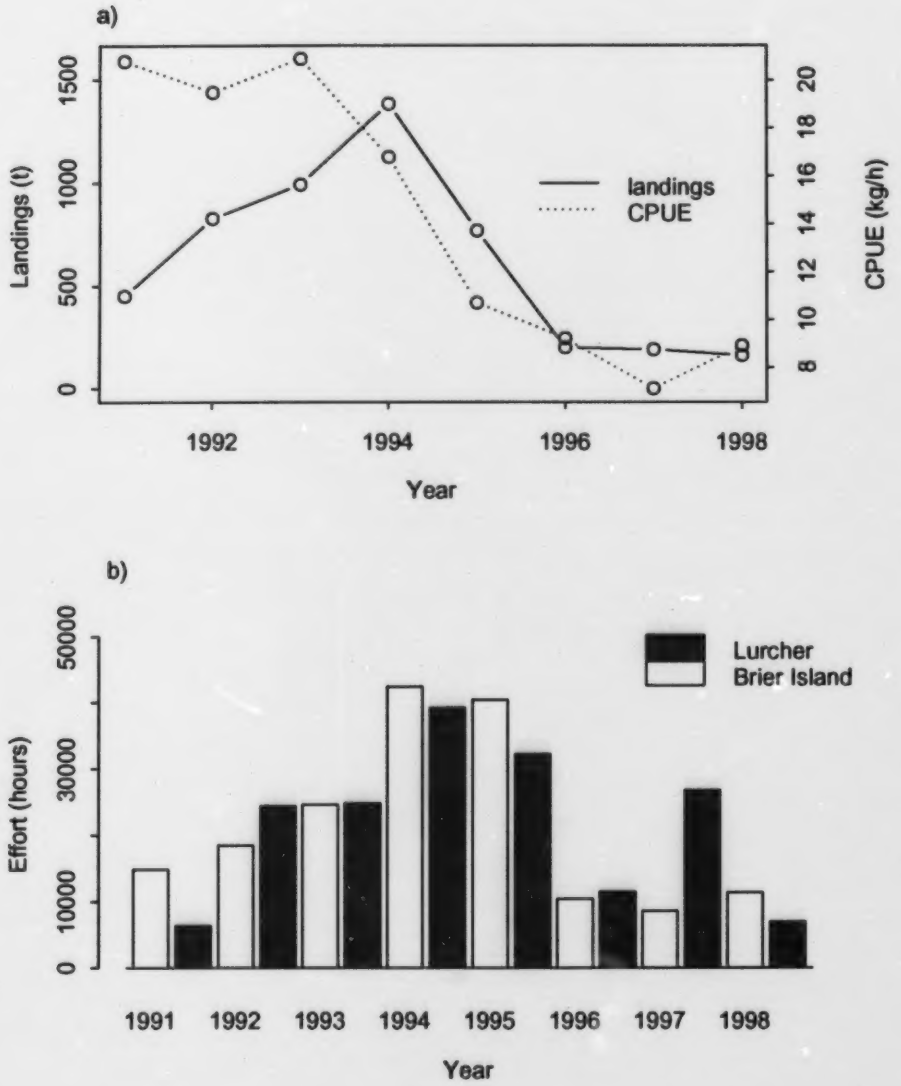

Fig. 2. Top panel: Scallop Landings (mt) and CPUE(kg/h) in SPA 3 1991–1998. Bottom panel: Effort in Brier Island and Lurcher Shoal subareas.

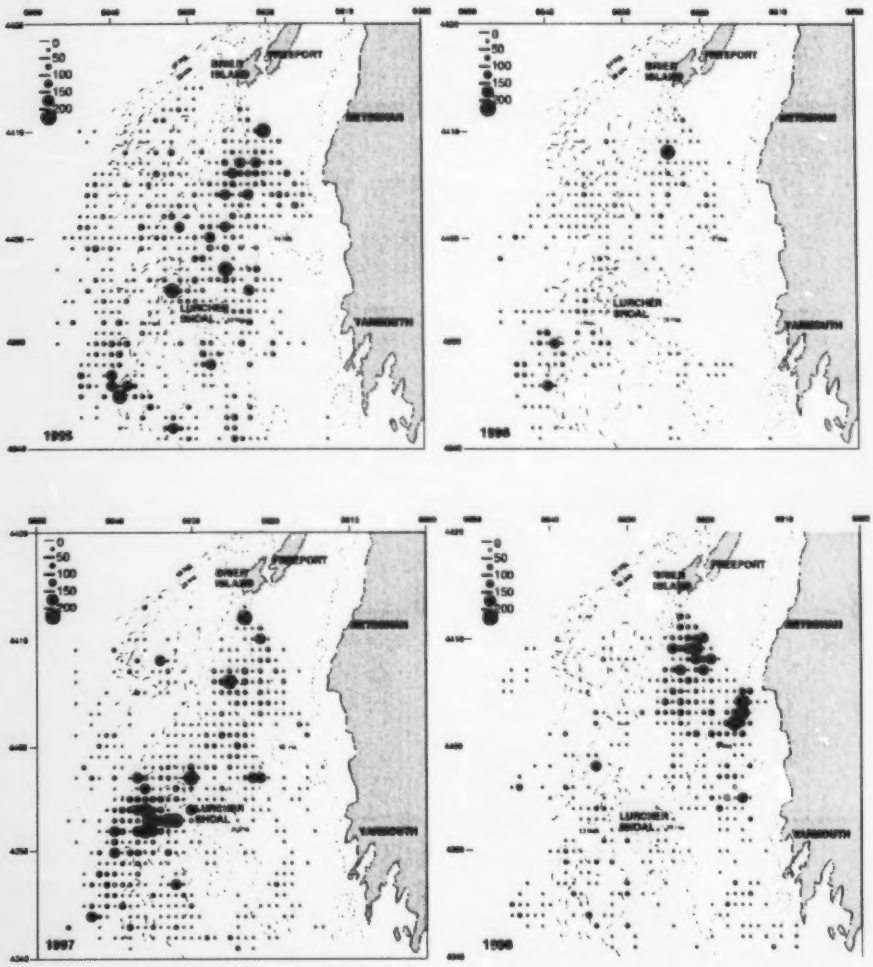

Fig. 3. Catch (kg) on the fishing grounds below Brier Island, (SPA 3), as calculated from fishing log information (class 1 logs only, see text). Increasing size of circles refer to increasing catch (scale in upper corner of plots).

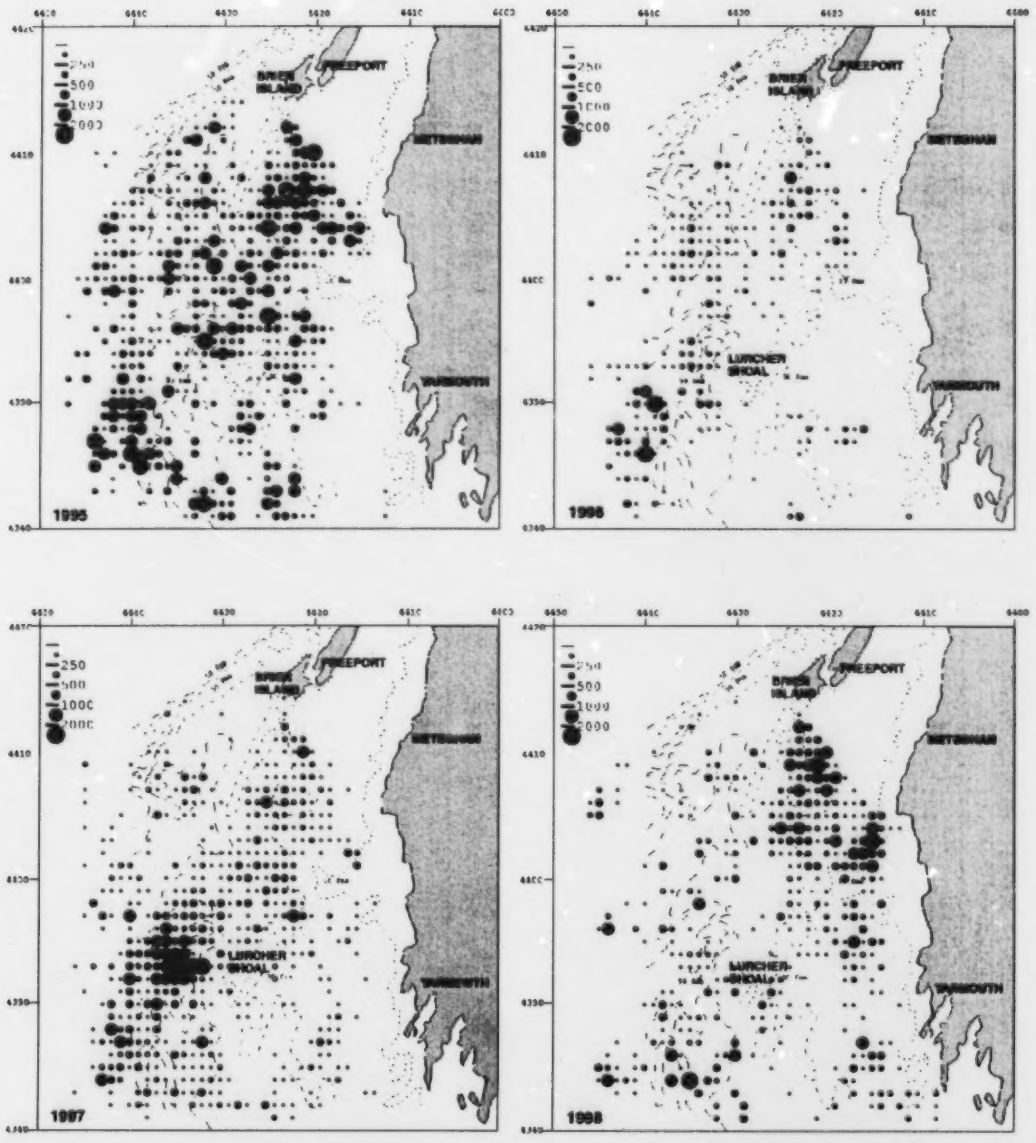

Fig. 4. Effort (hours) on the fishing grounds below Brier Island, (SPA 3), as calculated from fishing log information (class 1 logs only, see text). Increasing size of circles refer to increasing effort (scale in upper corner of plots).

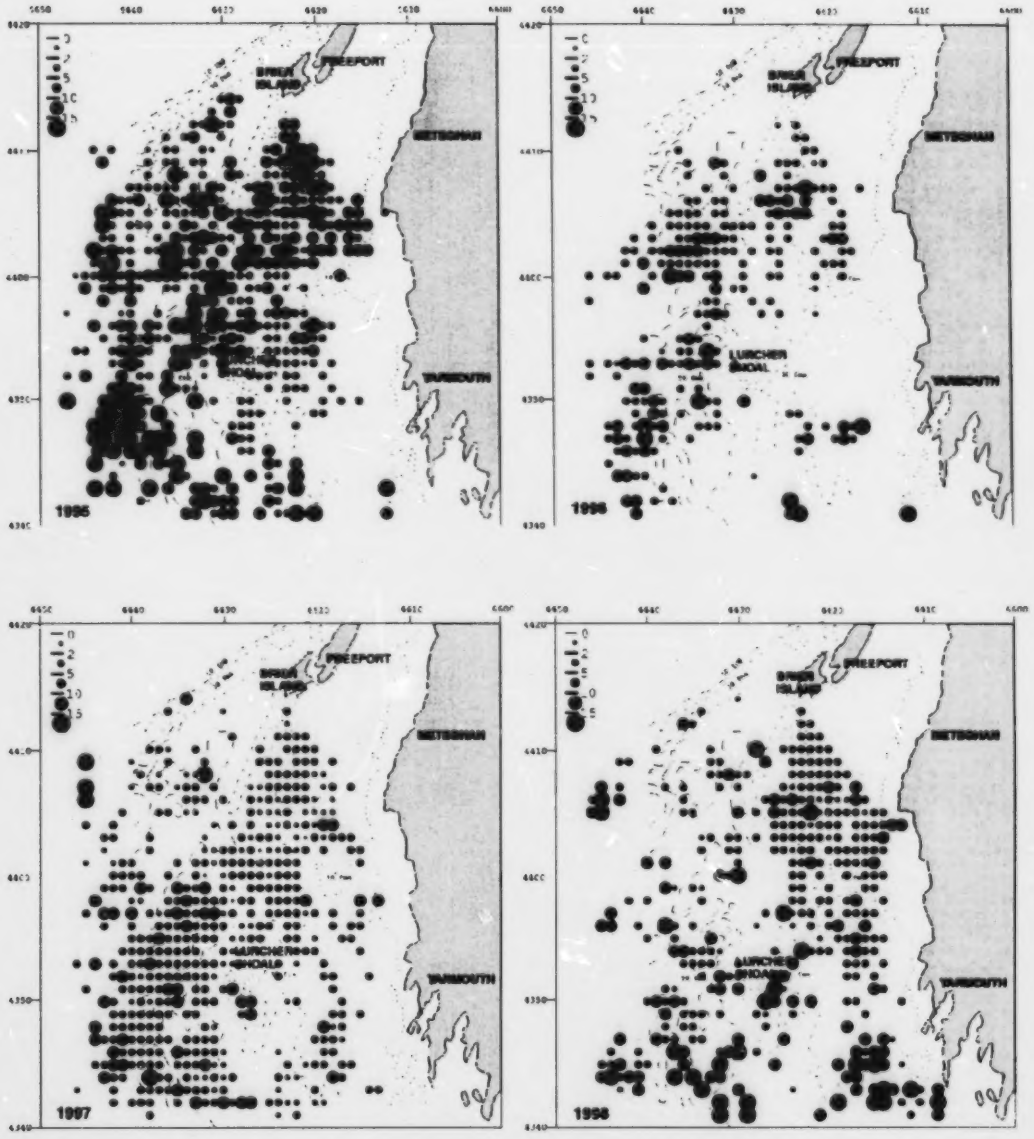

Fig. 5. Catch per unit effort (kg/h) on the fishing grounds below Brier Island, (SPA 3), as calculated from fishing log information (class 1 logs only, see text). Increasing size of circles refer to increasing catch per unit effort (scale in upper corner of plots).

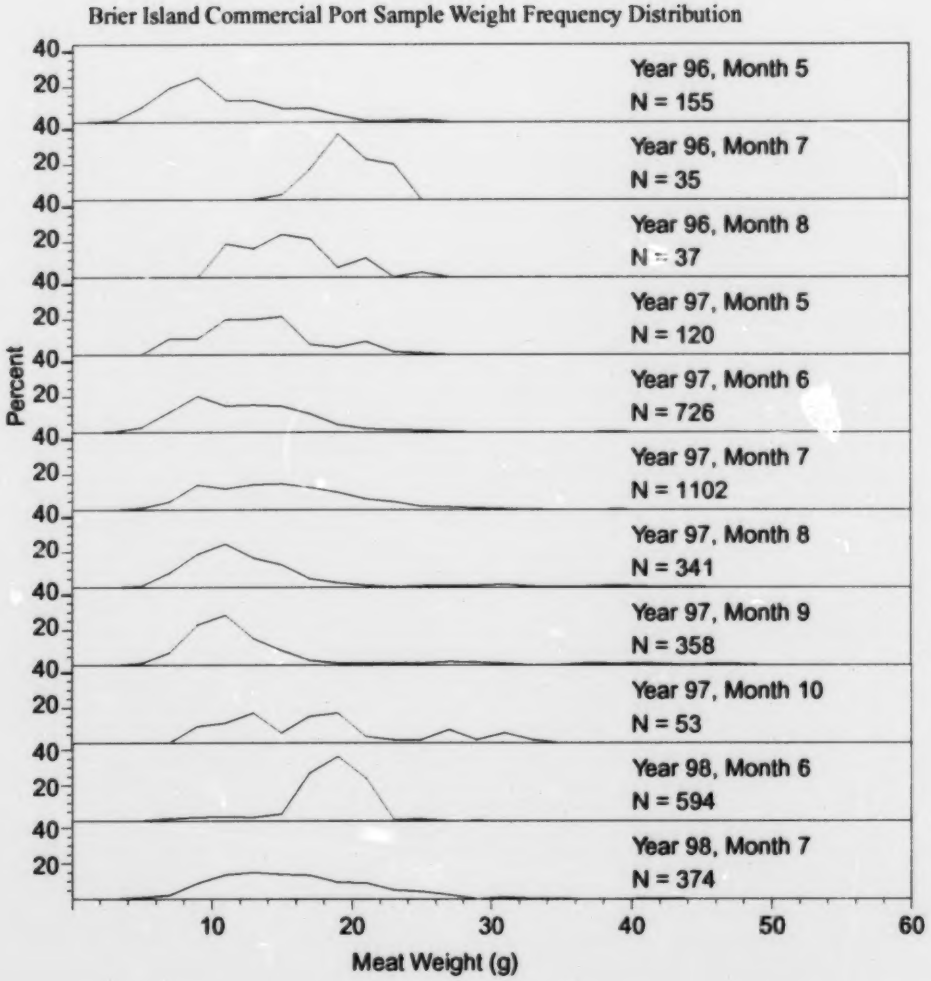

Fig. 6. Meat weight frequency distribution of the commercial port samples collected in 1996–1998 from the Brier Island subarea of SPA 3.

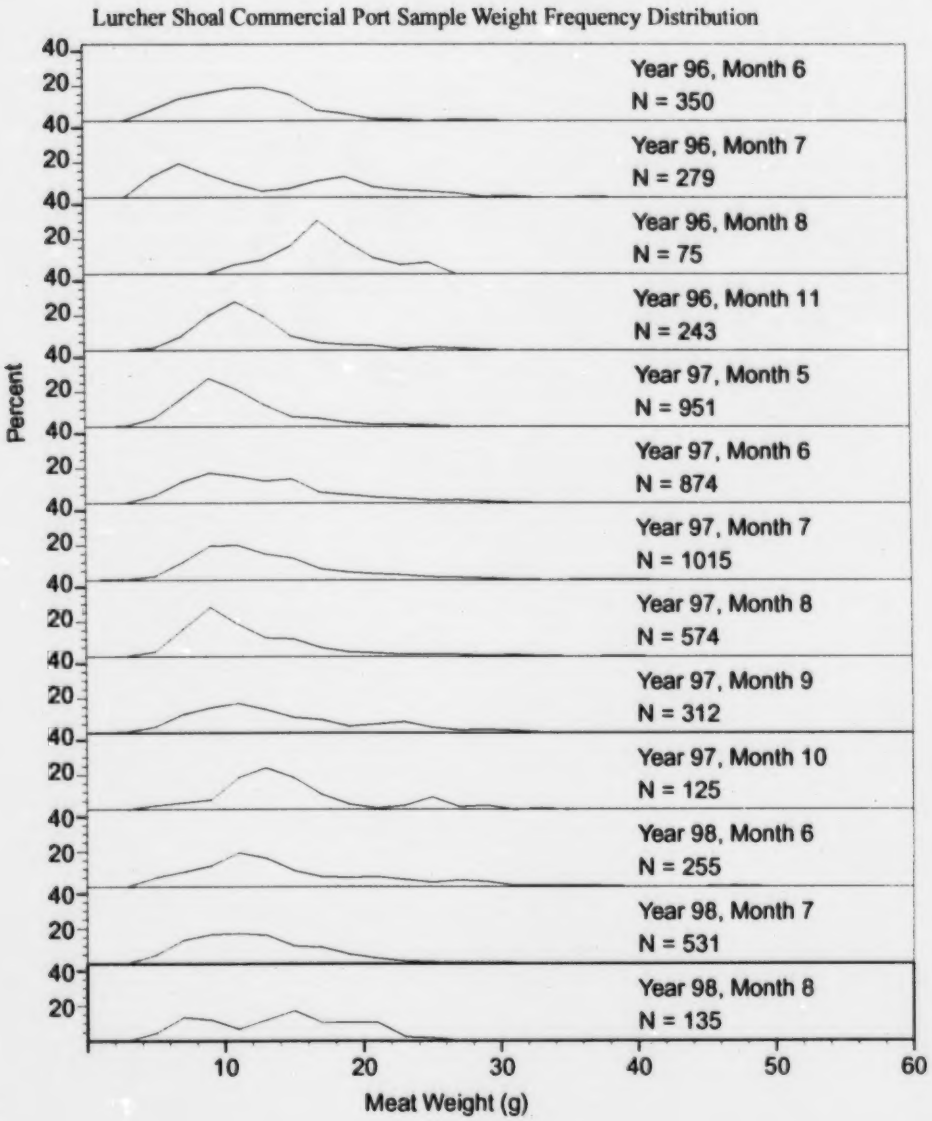

Fig. 7. Meat weight frequency distribution of the commercial port samples collected in 1996–1998 from the Lurcher Shoal subarea of SPA 3.

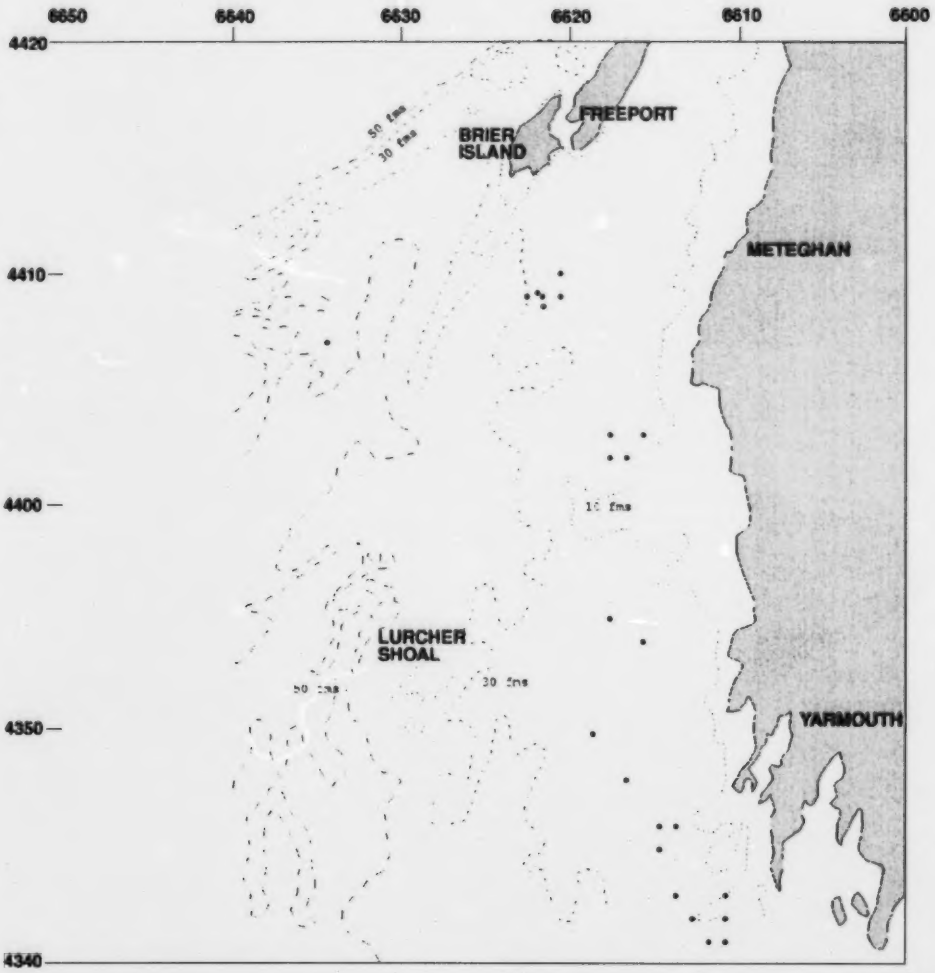

Fig. 8. Positions of commercial port sample fishing locations in 1998 indicated by dots.

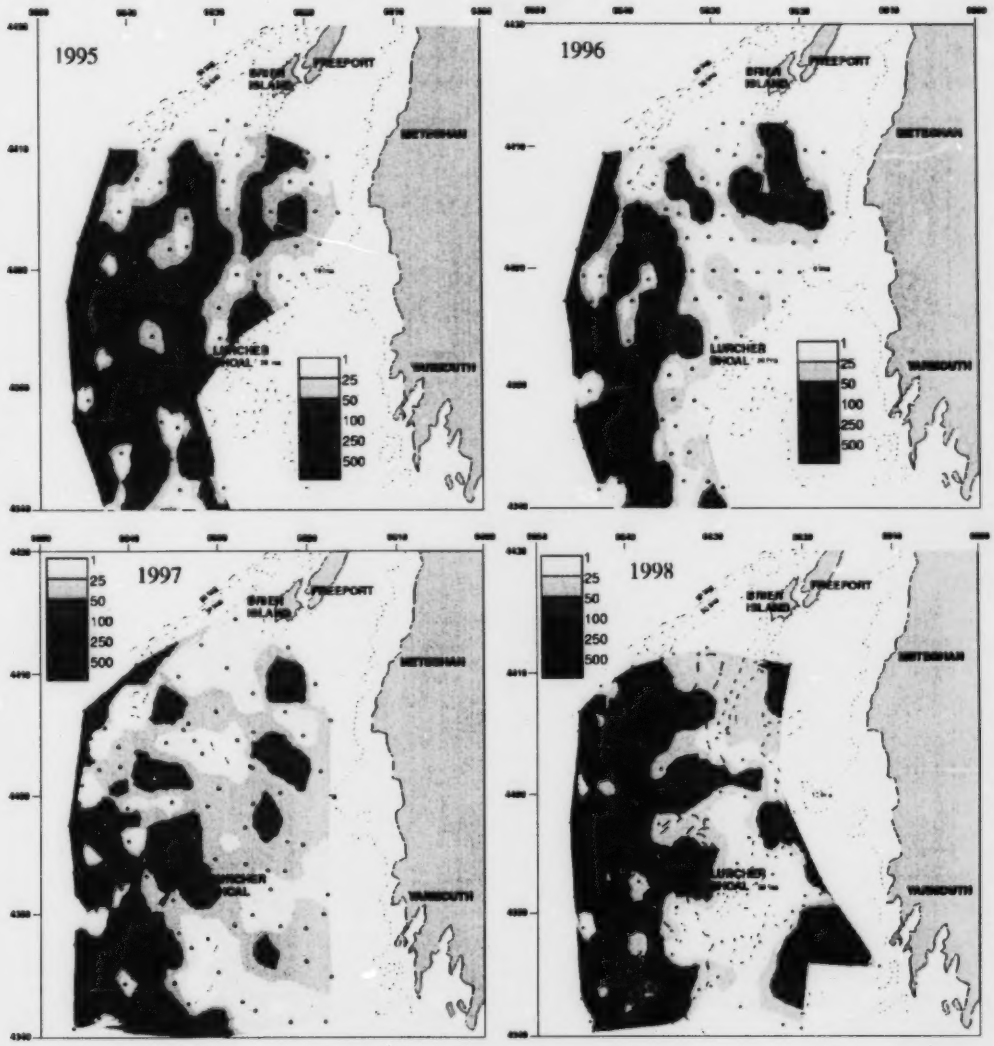

Fig. 9. Spatial distribution of scallops greater than 80 mm shell height caught during the 1995–1998 research surveys in SPA 3. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Dots depict tow locations.

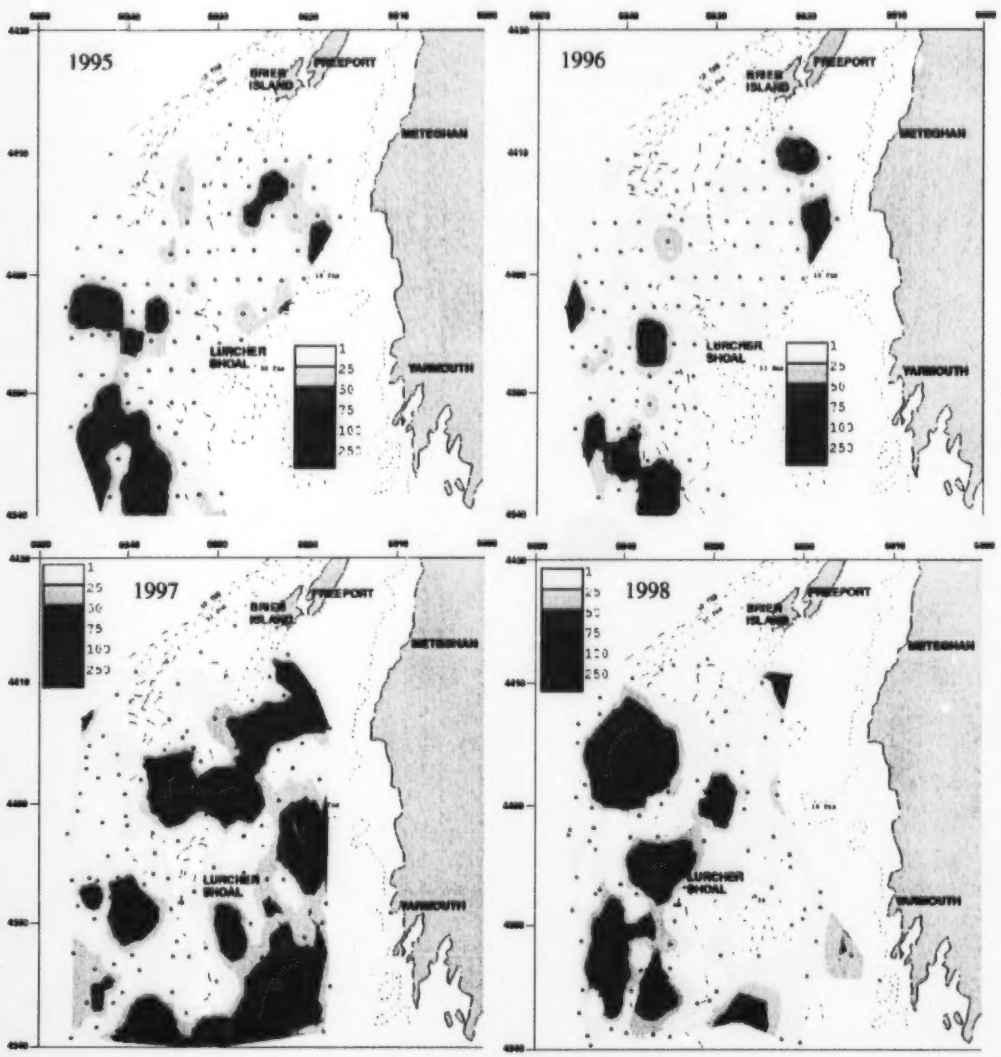

Fig. 10. Spatial distribution of scallops with shell height less than 80 mm shell height caught during the 1995–1998 research surveys in SPA 3. Darkening shades of grey within isopleths refer to increasing numbers of scallops per standard tow. Dots depict tow locations.

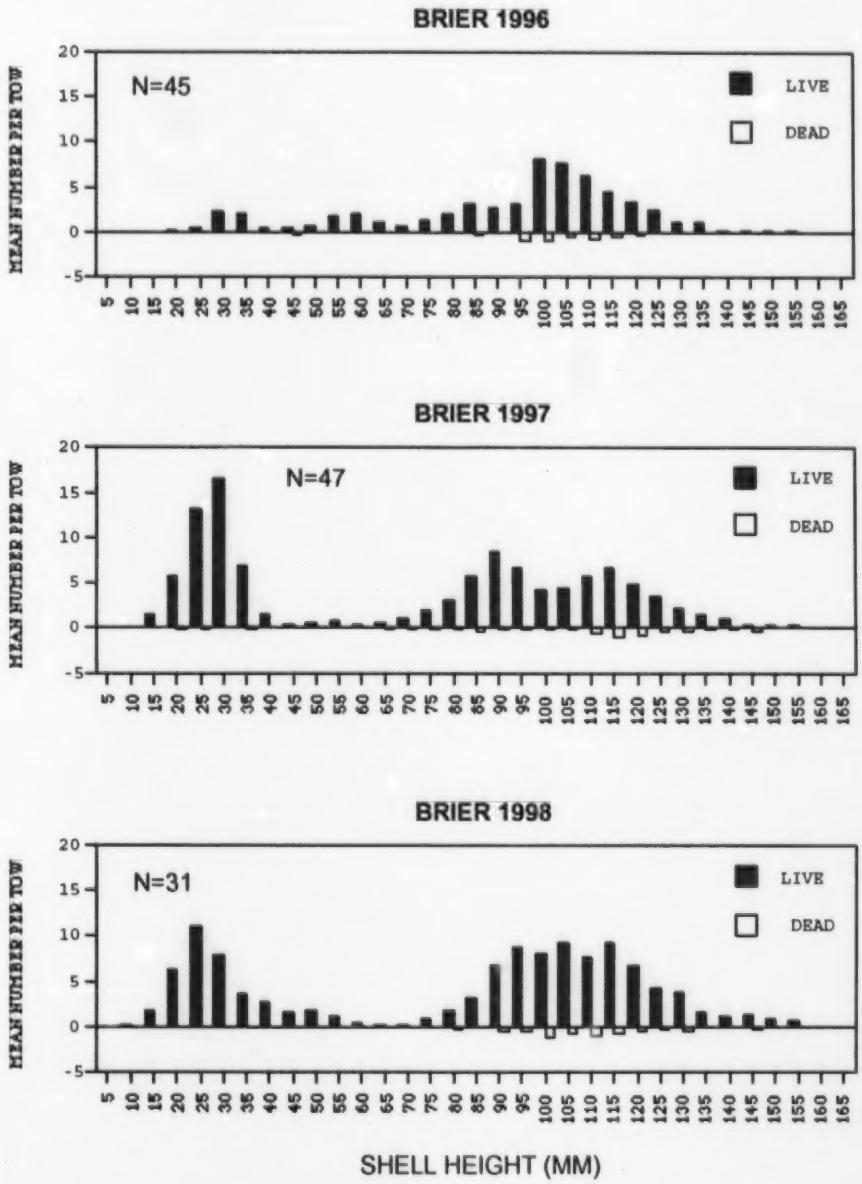

Fig. 11. Shell height frequency distribution of the mean number of scallops per tow caught in the Brier Island subarea of SPA 3 during the 1996–1998 stock surveys. The number of live and dead (clappers) animals is shown above and below the 0 frequency line, respectively. N = number of tows.

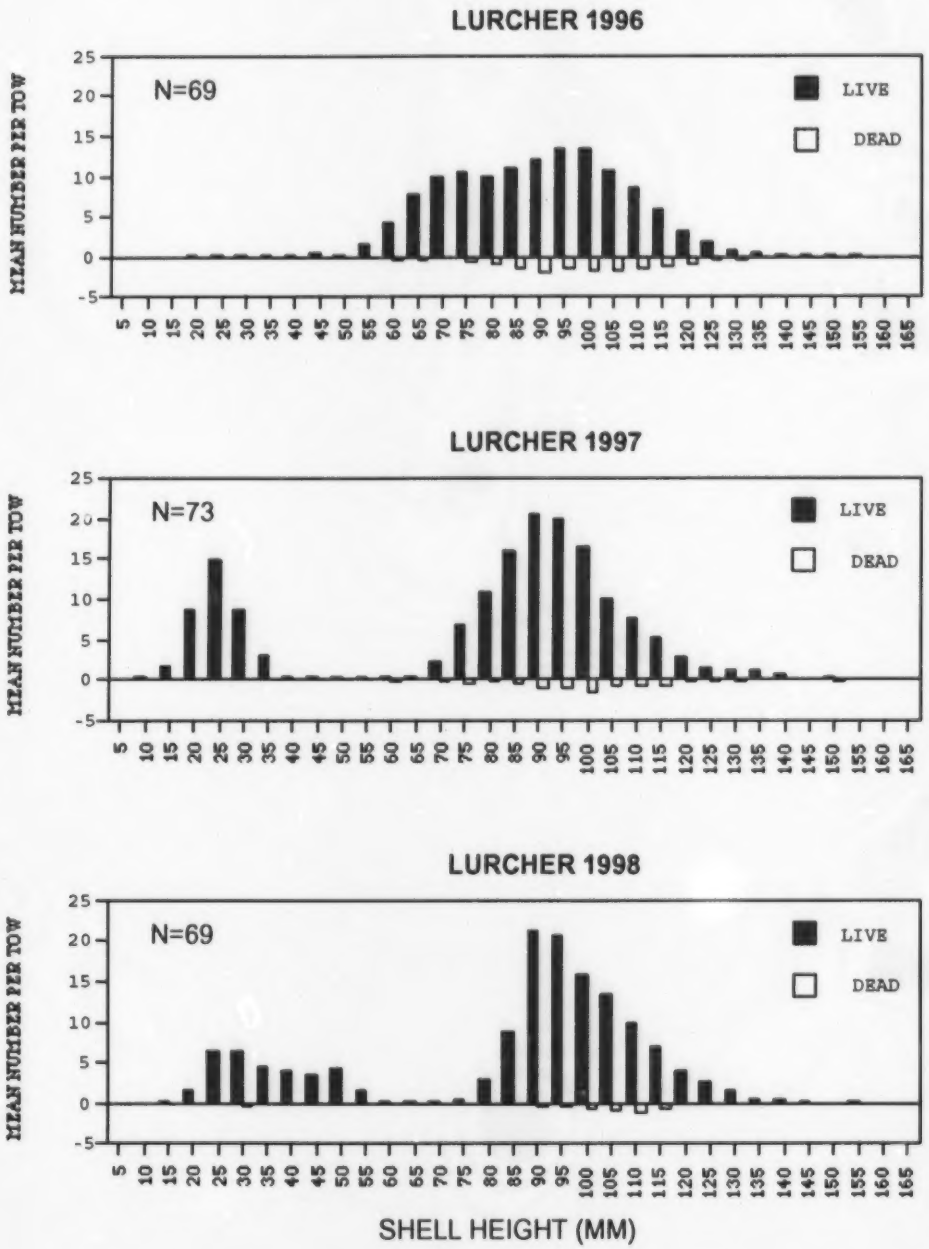

Fig. 12. Shell height frequency distribution of the mean number of scallops per tow caught in the Lurcher Shoal subarea of SPA 3 during the 1996–1998 stock surveys. The number of live and dead (clappers) animals is shown above and below the 0 frequency line, respectively. N = number of tows.

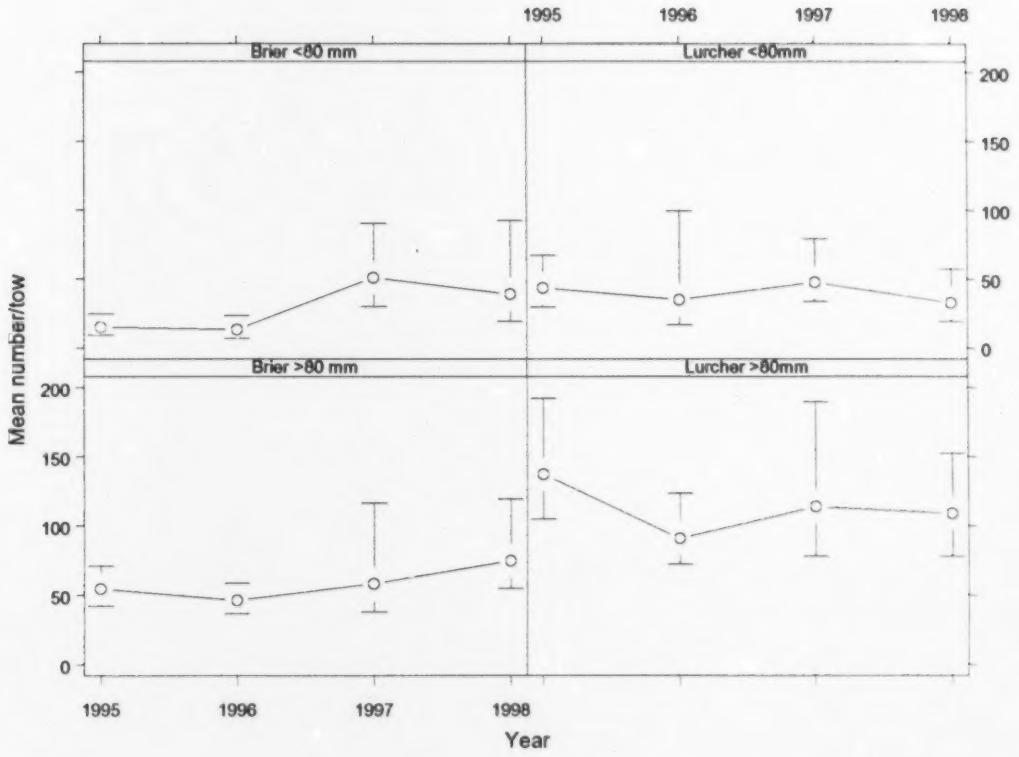

Fig. 13. Mean number of scallops per tow from August surveys for SPA 3, 1995–1998 for different size groups and areas. Upper and lower bounds refer to 95 percent confidence intervals calculated using bootstrap resampling and BCa percentiles (Efron and Tibshirani 1993).

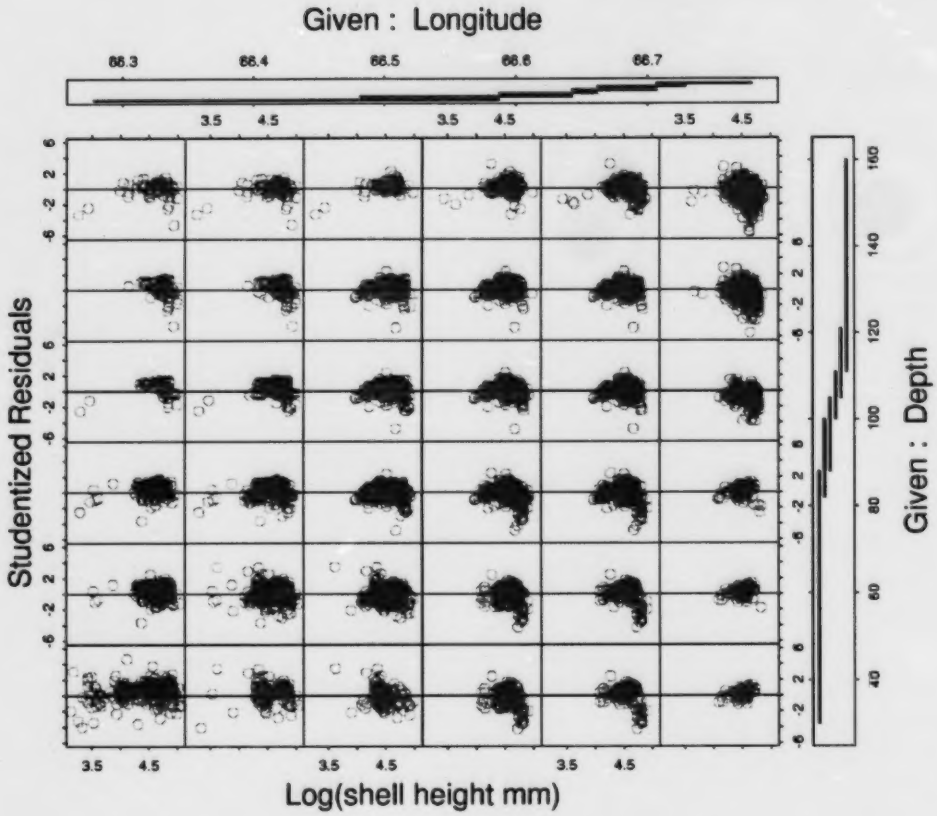

Fig. 14. Studentized residuals from log(meat weight)/log(shell height) regression plotted by depth range (rows) and Longitudinal range (columns) for data from 1996 scallop survey data for SPA 3.

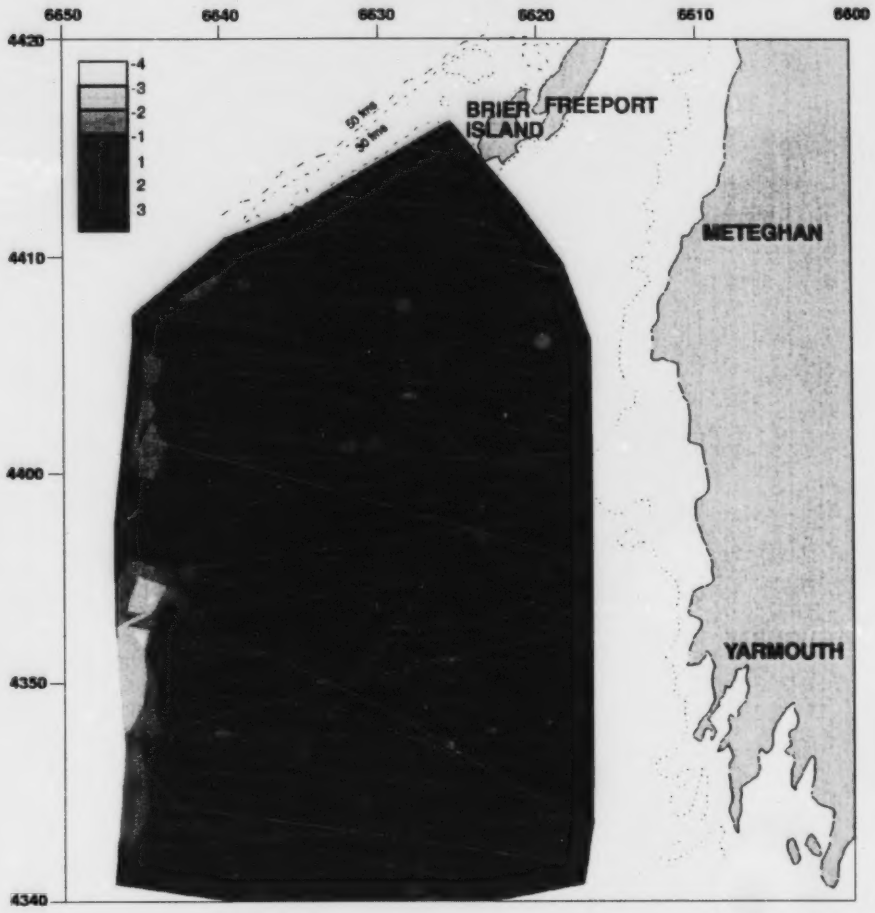

Fig. 15. Spatial distribution of residuals from regression model of log(meat weight) on log(shell height) by tow from the 1996 scallop survey data for SPA 3.

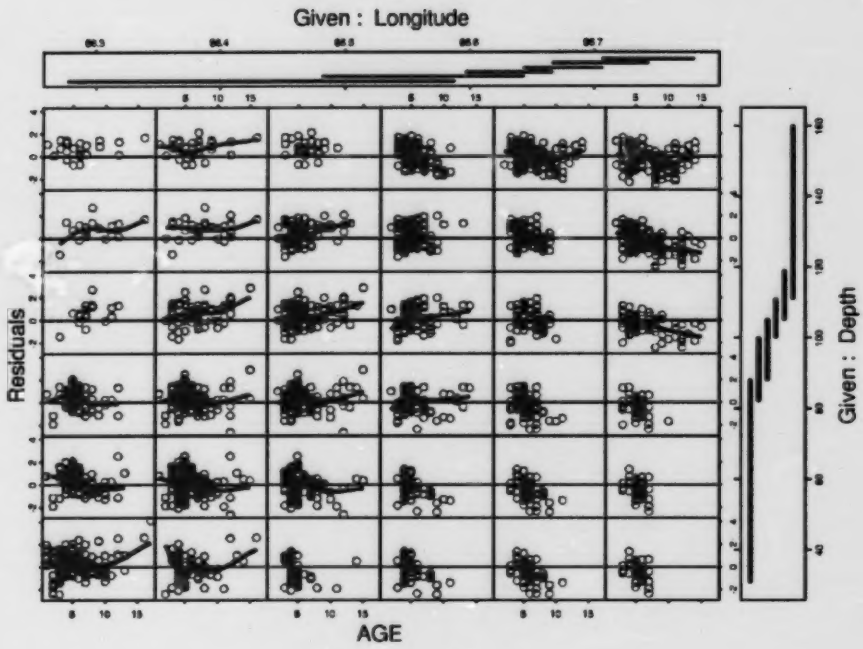

Fig. 16. Standardized residuals from Von Bertalanffy model fit of 1996 SPA 3 scallop growth data from Kenchington and Lundy (1998). Residuals plotted by depth range (rows) and Longitudinal range (columns).

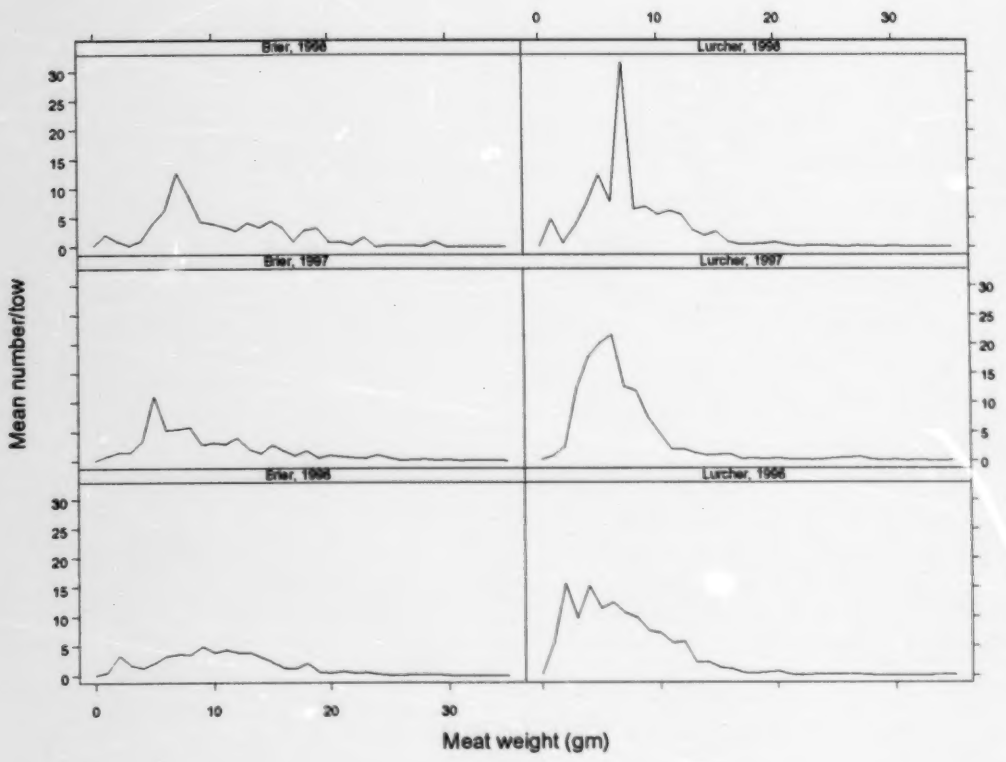

Fig. 17. Meat weight frequency distribution of the mean number of scallops per tow caught in the SPA 3 during the 1996–1998 stock surveys.